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F03B 13/22 13/26

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(58) Field of Search
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(54) Column mounted water current turbine

(57) A turbine rotor assembly has blades 1 mounted for rotation relative to nacelle 2, which contains electricity generating means (fig. 2). The turbine and sleeve 3 can swing around a vertical column 4 to align with the flow of water. The turbine assembly can also be raised or lowered with respect to the column, and thus with respect to the surface of the water. The turbine may be raised above water for maintenance (figs. 6, 10, 12). A counterbalance weight 35 may be provided (fig. 12). A plurality of turbines may be mounted on one column (fig. 8).

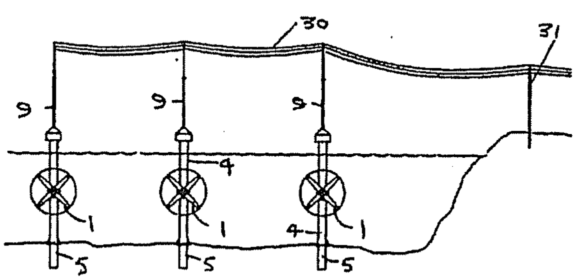

Fig 7

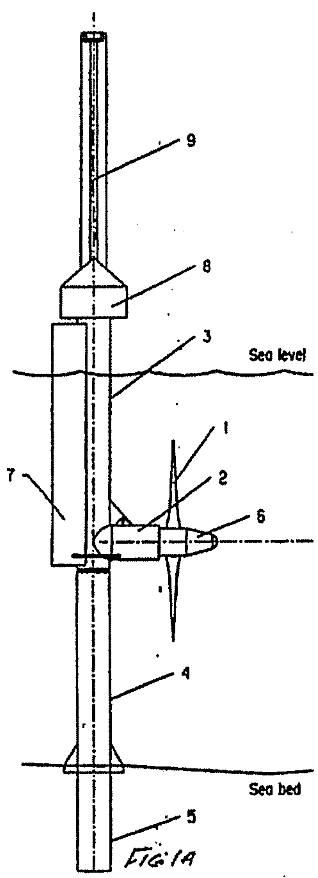

FIG 1A

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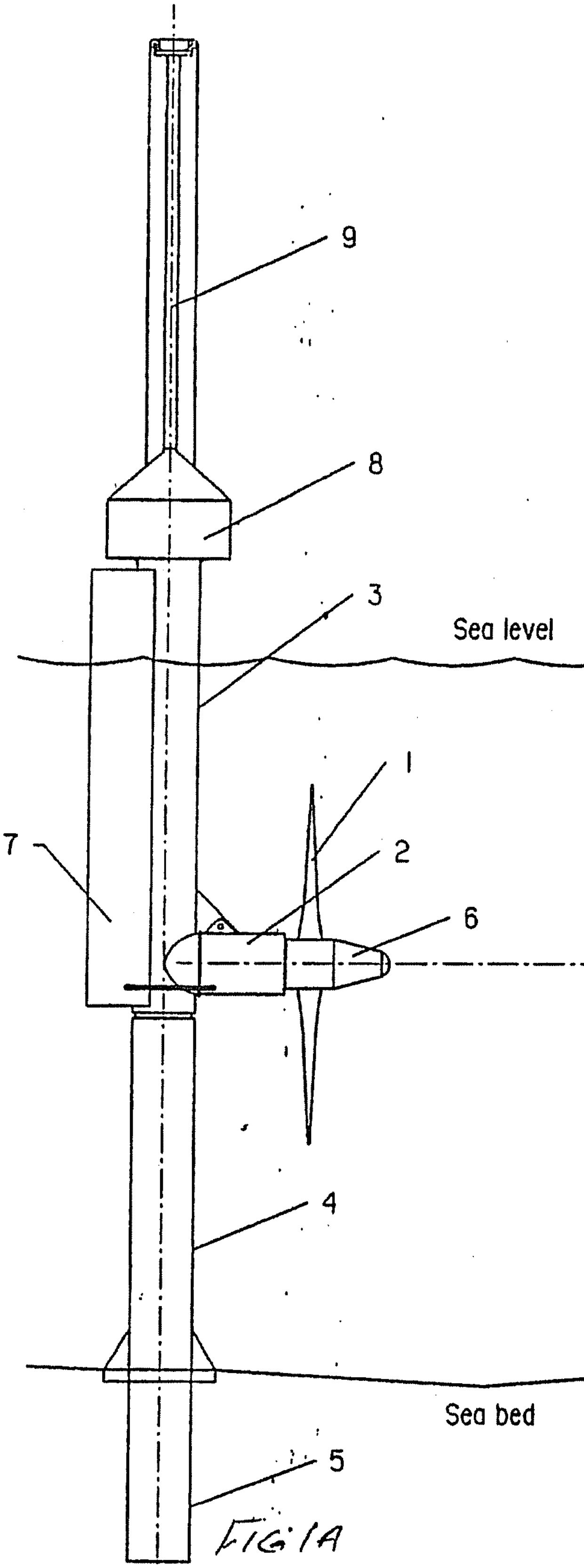

FIG 1A

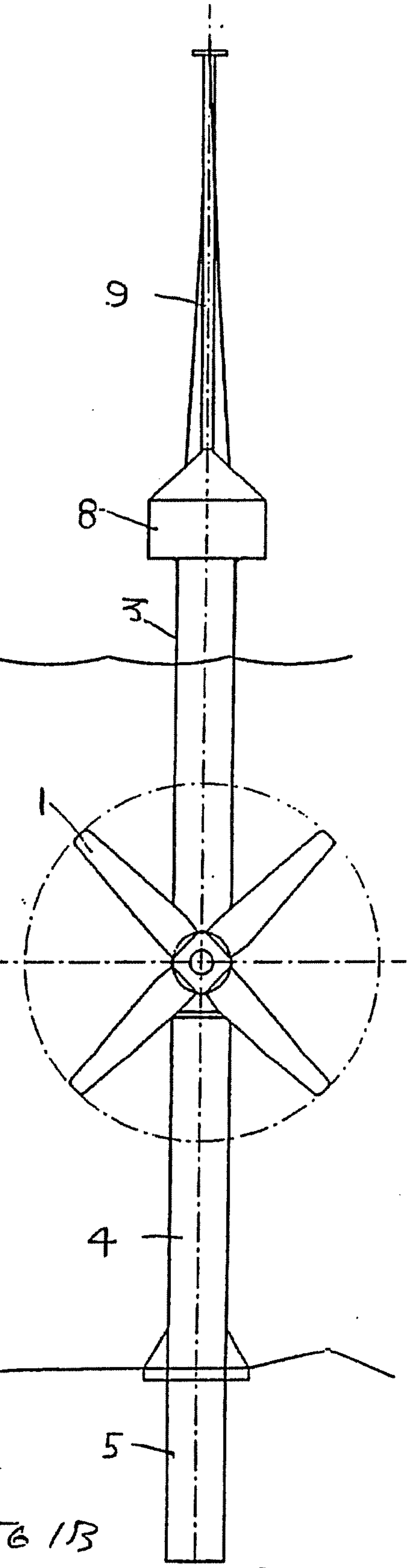

FIG 1B

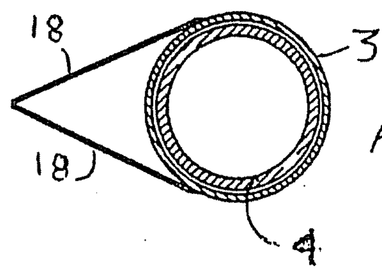

FIG 2A

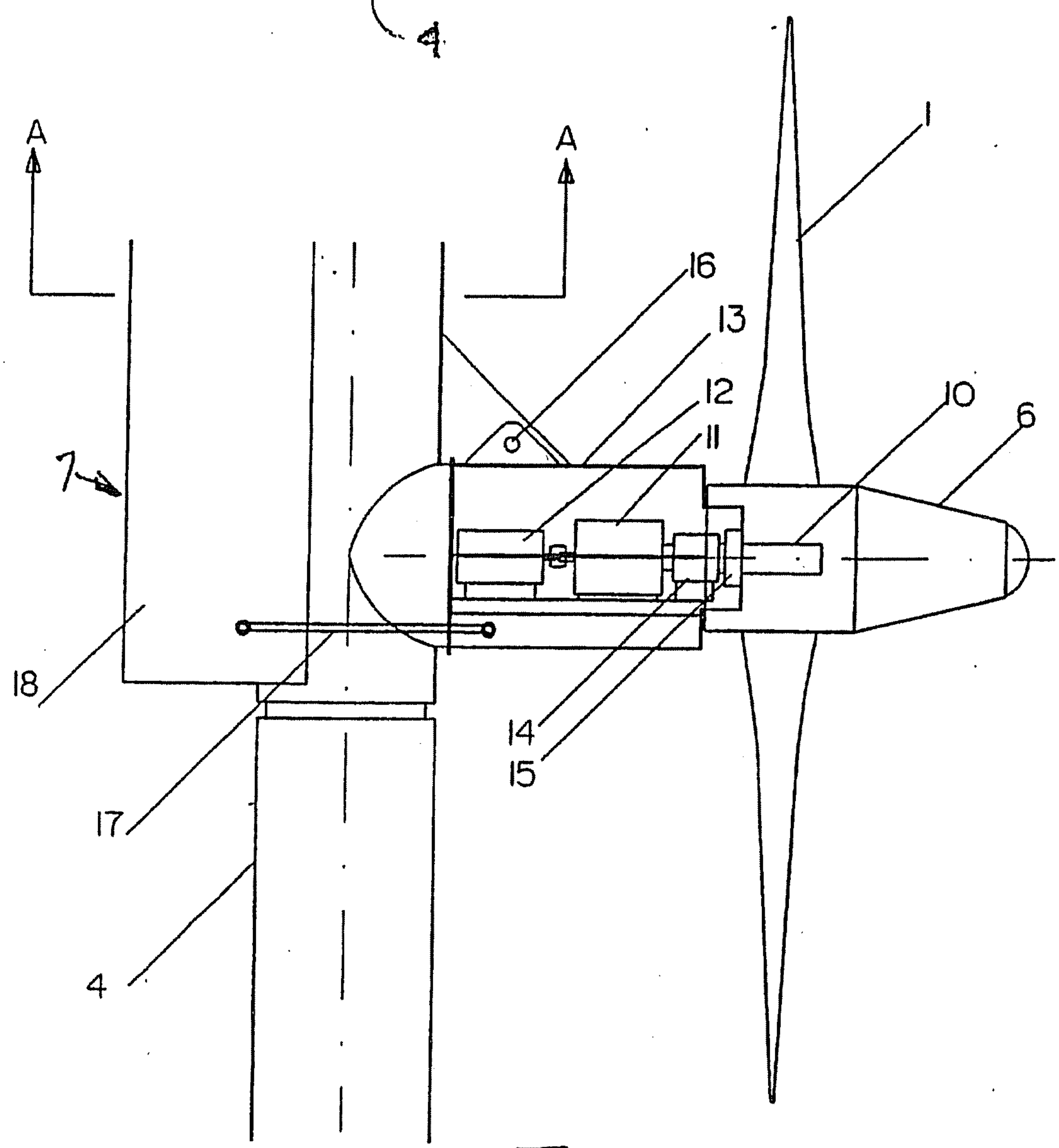

FIG 2

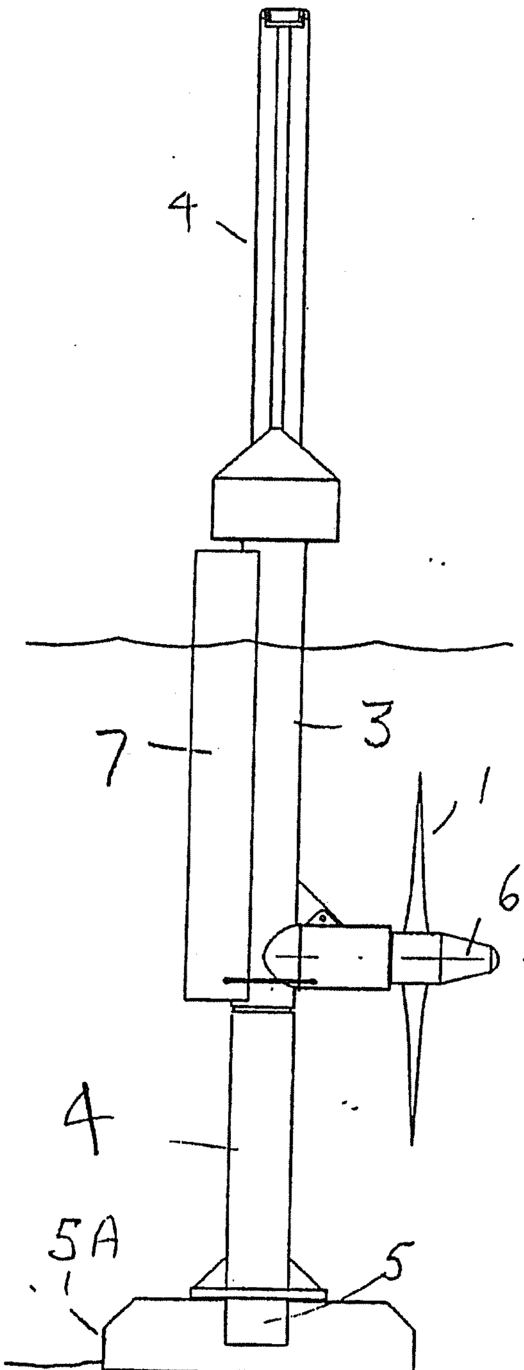

FIG 3

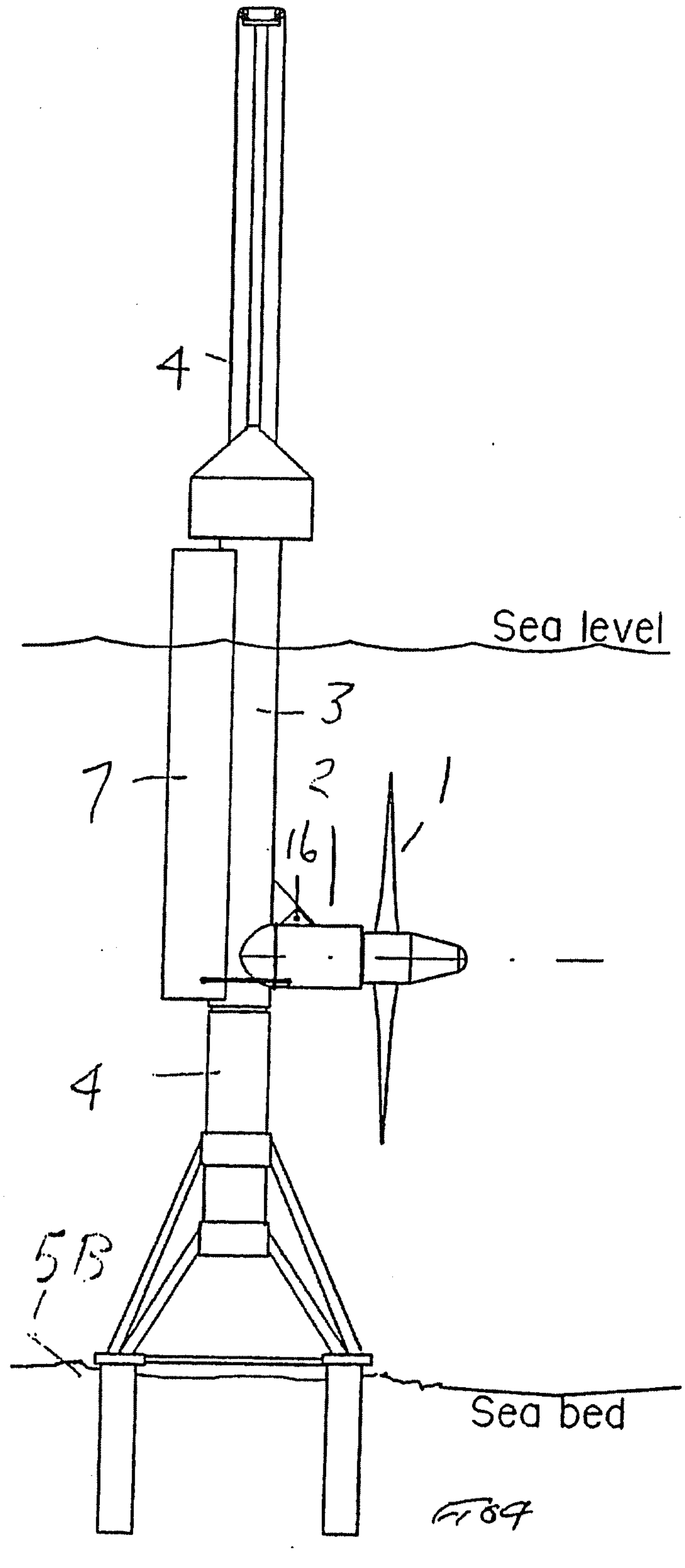

FIG 4

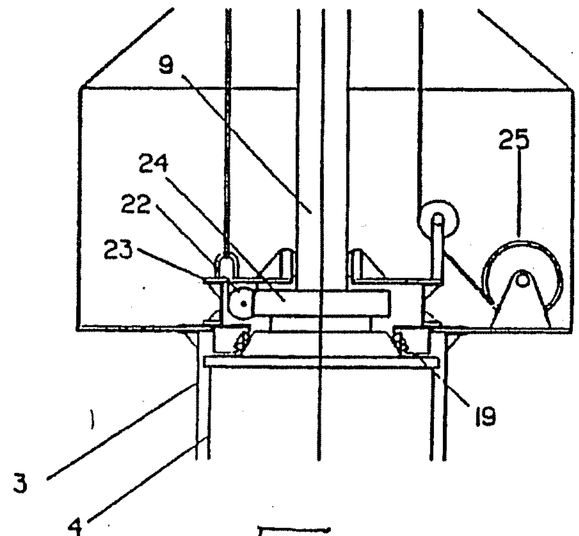

FIG 5B

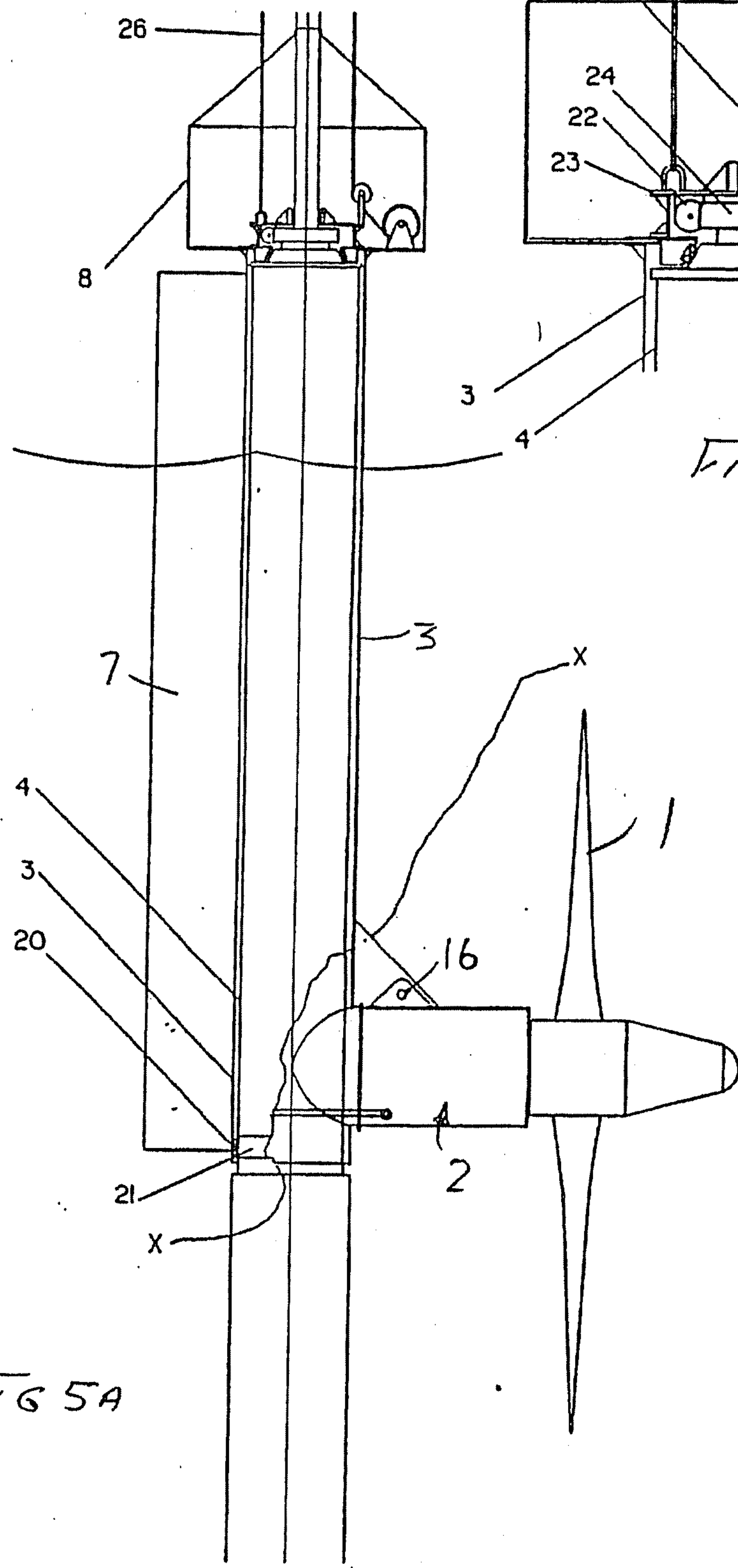

FIG 5A

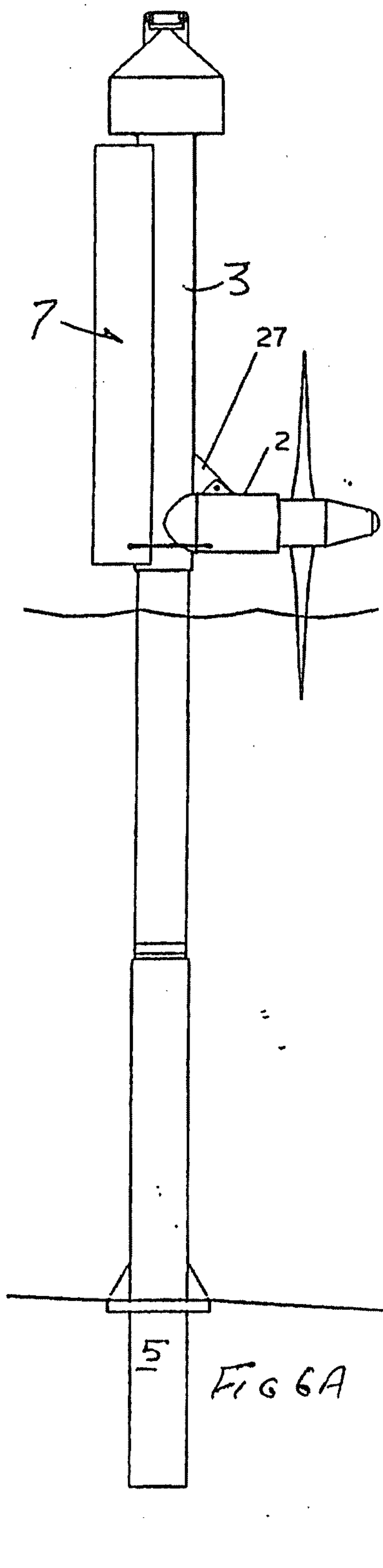

FIG 6A

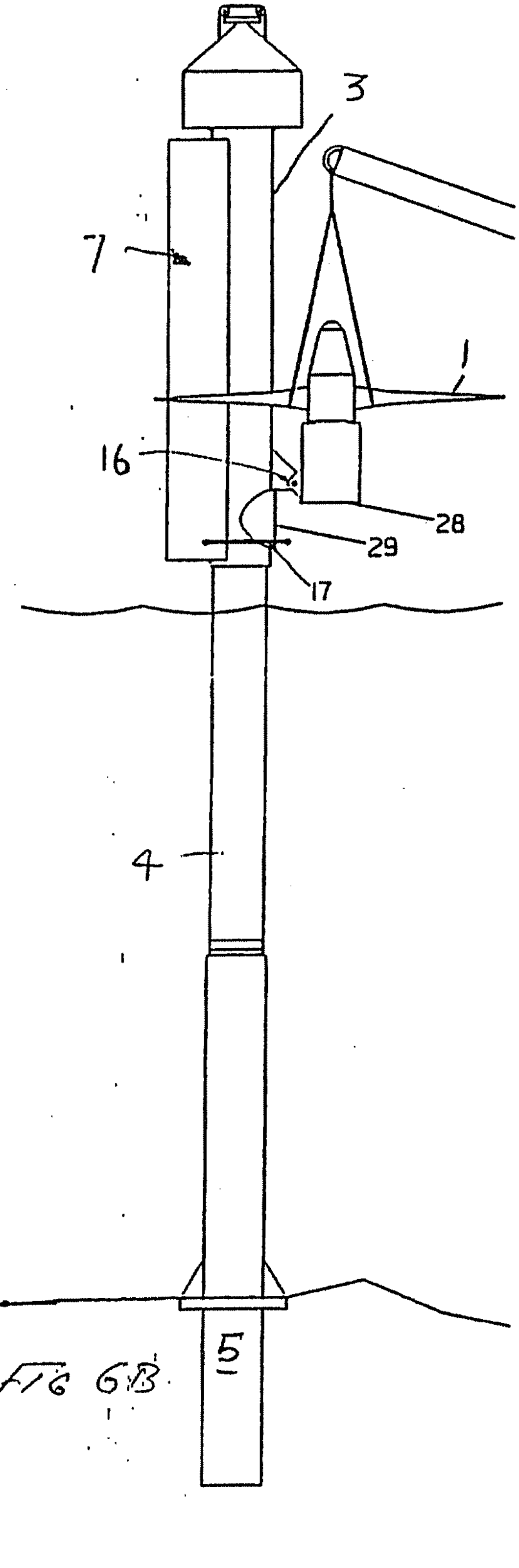

FIG 6B

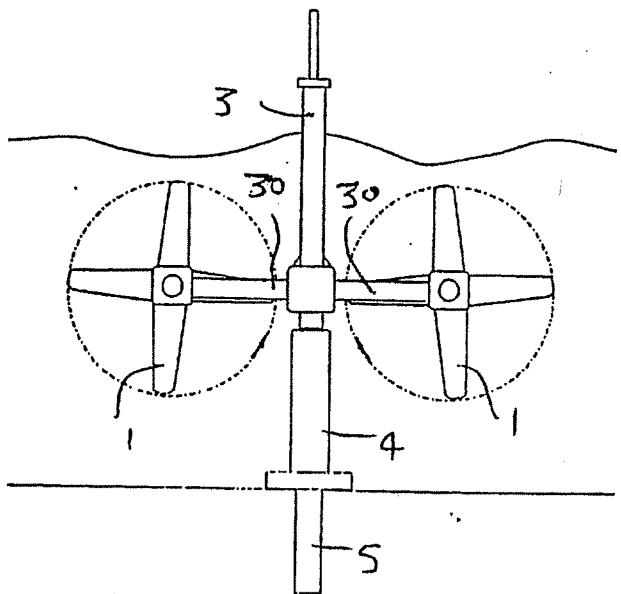

FIG 8

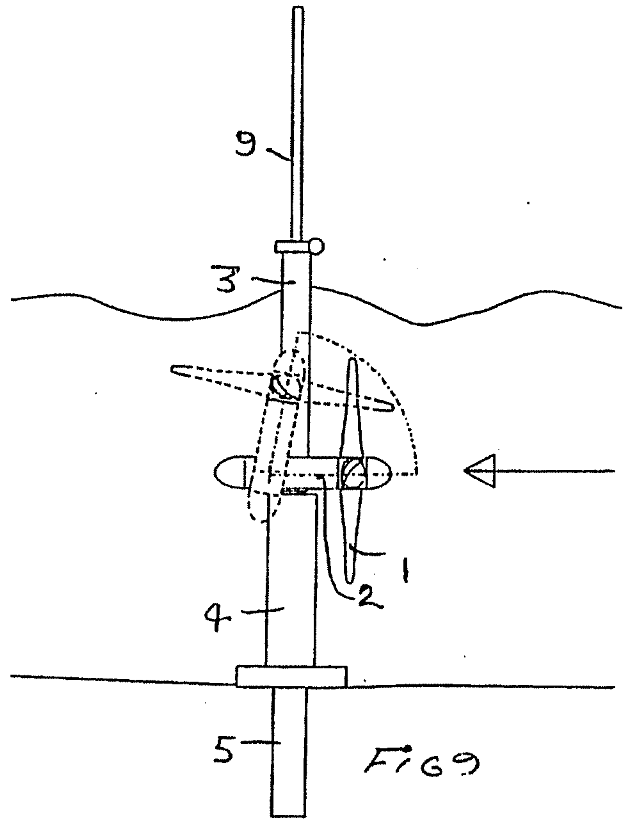

FIG 9

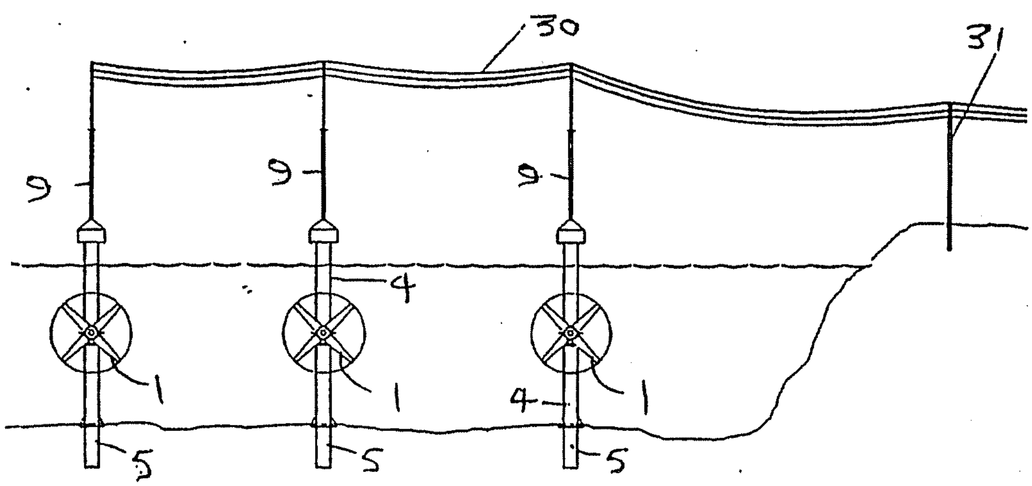

FIG 7

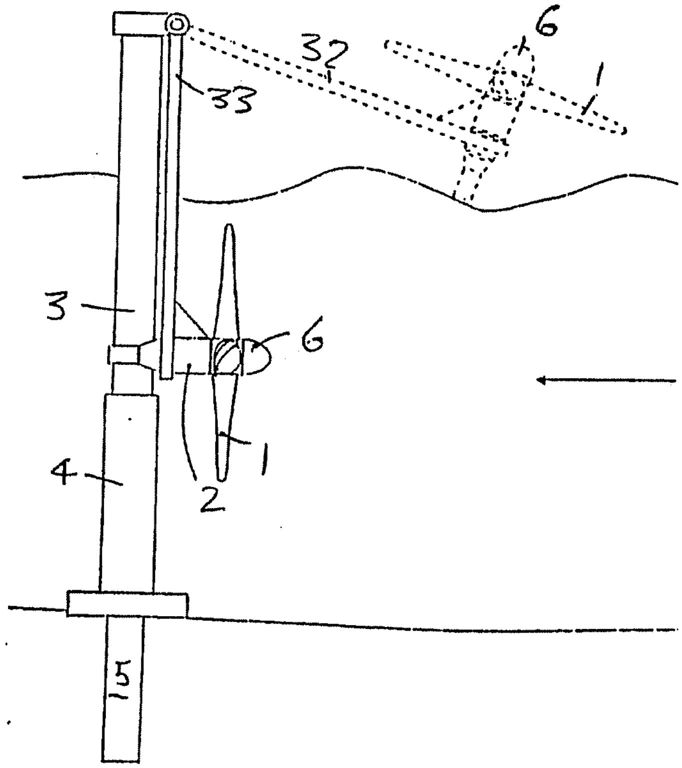

FIG 10

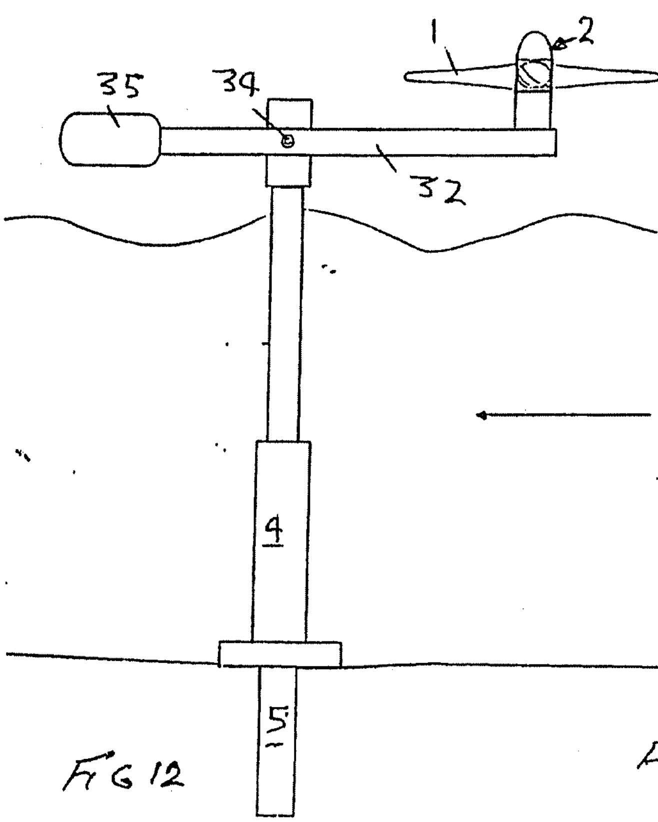

FIG 12

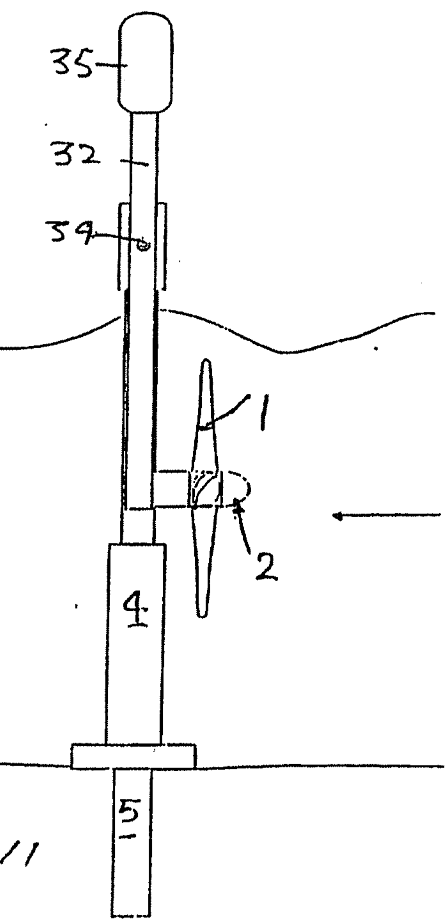

FIG 11

COLUMN MOUNTED WATER CURRENT TURBINE

This invention relates to turbines, and more particularly with turbines arranged to be driven by the action of a flow of water.

Flowing water is a characteristic of tidal, marine, esturial or river currents.

Thus, the present invention relates in particular to the use of turbines for extracting kinetic energy from flowing water for the purposes of utilising such kinetic energy to produce either electricity or shaft power for utilisation for a required purpose.

It is known how to use turbines for such purposes.

As is known a turbine intended for extracting kinetic energy from water currents, whether in a river or at sea, generally includes a rotor capable of interacting with the flow of water in such a way that some of the energy motion of the passing mass of water causes the rotor to rotate. The rotation of the shaft of the rotor is utilised to perform some useful function such as to generate electricity. Such a device is analogous in principle to the better known concept of the windmill or wind turbine which extracts kinetic energy from flowing air, except that due to the much greater density of water as compared to that of air lower fluid flow velocities (by a factor of approximately 9) are needed to give the same power density (power per unit area of flow) i.e., water moving at 1m/s has a similar power density (e.g,Watts per square metre) as air moving at 7.5m/s.

It is also to be noted that although the physical principles involved in extracting kinetic energy from water currents are similar to those involved in the better known art of extracting kinetic energy from the wind, the actual forces involved and the practical engineering requirements for the formation of a suitable installation are in most respects technically different.

In practice, tidal, marine and river currents generally have their maximum velocity near to the surface thereof so that any device intended efficiently to intercept the kinetic energy of the currents needs to have its rotor set so that its active plane or cross section is perpendicular to the direction of water flow and as near to the surface as possible. Any such device also needs to be securely positioned in such manner as to resist the considerable drag forces and reaction forces associated with moving water. In practice, the main drag force is an axial thrust in the direction of current flow due to the momentum deficit in the flow, which thrust is proportional to the area of the active rotor and the velocity squared. There is also a significant torque reaction to be resisted. Furthermore, means has to be provided to convert slow rotational rotor movement produced by the water flow into a useful energy form that can be effectively transmitted from the generation location to a location at which it can be gainfully employed.

For a practical installation there are other important factors that need to be addressed. In the case of marine applications such factors include the need to resist damage from large waves during storms, the need to make the device visible to minimise it as a hazard to shipping and the need to be able to service and repair as well as

to deploy the device at sea both safely and at minimum cost.

It is an object of the present invention to provide a turbine system which takes into account the factors or matters mentiuoned above.

Broadly, according to the present invention there is provided a flowing water actuatable turbine system, wherein the turbine is mounted for operational cooperation with a water current by means of an upstanding column.

Broadly, in accordance with such aspect of the invention the system includes a turbine assembly mounted for rotation about the upstanding axis of the column, the arrangement being such that the turbine assembly can be enabled operationally to undergo yaw with respect to a direction of water flow thereby to cause the rotor assembly operationally to align with the flow of water.

According to a second aspect of the invention, there is provided a water drivable turbine system including a turbine rotor assembly mounted for rotation about the longitudinal axis of a vertically arranged column whereby the turbine assembly can be enabled operationally to align with the flow of water, and wherein the mounting of the turbine assembly to said column is such that the turbine assembly can be raised or lowered with respect to the column and thus with respect to the surface of the water

Preferably, the turbine assembly is in turn mounted upon a sleeve like housing carried by the column in such manner that the sleeve is both vertically displaceable and rotatable with respact to the column.

Preferably the turbine assembly includes a nacelle shaped to optimise water flow thereby and wherein the rotor of the assembly is located towards an end of the nacelle, the shaping of the hub region of the rotor being such as effectively to form part of the overall shaping of the nacelle.

For a better understanding of the invention and to show how to carry the same into effect reference will now be made to the accompanying drawings in which :-

Figure 1A is a schematic side view of an embodiment of a flowing water turbine system incorporating the concepts of the invention;

Figure 1B is a front view of the turbine system of Figure 1;

Figure 2 is a sectional view at the reguon X-X to an enlarged scale of a turbine nacelle and rotor of the turbine system shown in Figures 1A and 1B;

Figure 2A is a section on the line A-A of Figure 2;

Figure 3 schematically illustrates an alternative mounting for use with the turbine system;

Figure 4 schematically illustrates the use of a multiple piles jacketed structure for mounting the turbine system shown in previous Figures;

Figure 5A schematically illustrates arrangements for yawing/slewing the turbine rotor about a vertical axis.

Figure 5B is an enlarged view of a detail of the arrangements of Figure 5A;

Figures 6A and 6B schematically illustrate a method of mounting and demounting a turbine assembly from its operational support arrangements;

Figure 7 schematically illustrates an arrangement for electrically interconnecting a plurality of individual turbine assemblies as illustrated in the previous Figures;

Figure 8 schematically illustrates an embodiment of a turbine system incorporating twin rotors;

Figure 9 schematically illustrates a mode of providing for the yawing of the twin rotors of Figure 8 about a horizontal orthogonal axis.

Figures 10 schematically illustrates an alternative method of mounting a turbine system from its supporting column;

Figures 11 schematically illustrates a still further alternative method of mounting a turbine system from its supporting column, the Figure illustrating the turbine system in its operational setting; and

Figure 12 schematically illustrates the arrangement of Figure 11 when the turbine system is displaced from its operational setting.

Referring to the drawings and more particularly to Figures 1A and 1B, in these Figures the water surface level is identified as 'sea level' and the surface of the sea floor as 'sea bed'. In principle this could equally relate to

a river or estuary.

The turbine system illustrated in the Figures 1A and 1B includes a turbine rotor 1 mounted for rotation on a nacelle 2, containing power generation equipment such as an electrical generator, hydraulic pump or the like, which is in turn mounted upon a vertically arranged sleeve 3 which is carried by a vertical column 4 anchored in the manner of a pile into the sea bed. As shown, a suitable length 5 of the column is submerged in the sea bed. It will be appreciated that the column length 5 can be inserted into a previously drilled hole and set into position in conventional manner i.e., the column can be held in place as a monopile or by a plurality of piles.

As will be noted from the Figures 1A and 1B the column 4 and at least a portion of the sleeve 3 project above the sea level, this being a preferred but not necessarily an essential feature of the construction of the column and sleeve combination. However, in most but not necessarily in all cases it is possibly advantageous for the internal column 4 to be tall enough to pierce the surface of the water under all operating conditions.

Figure 3 schematically illustrates an alternative mounting for the turbine system involving the placement of adequate concrete foundations structures 5A.

The column can also be erected using a multi-pile arrangement 5B. This is schemetically shown in Figure 4.

The sleeve 3 is supported with respect to the column by a thrust bearing 8, (see Figure 5) the function of which will be discussed in some detail hereinafter. The thrust bearing allows the sleeve to rotate about the column 4.

The lower end of the sleeve is positionally constrained

relative to the column 4 by a bearing arrangement to be discussed hereinafter.

By mounting the sleeve 3 so that it is capable of rotation about the column 4 it is possible for the nacelle and the rotor carried thereby to to orient in yaw so as to face in any desired direction in the horizontal plane.

The opposite side of the sleeve 3 to the nacelle and rotor (the downstream side) carries an optional shaped compartment or faring 7 which will be generally water tight. Likewise the nacelle 2 is provided with a suitably shaped faring 6. Further discussion will be provided in connection with the function of these farings hereinafter.

Referring now to Figures 2 and 2A, these Figures as mentioned show to an enlarged scale and in schementic form detail of the construction of a nacelle and its mounting to the sleeve 3.

The rotor 1 can be fabricated from various materials and methods. For example, the materials can include steel plate, ferro-cement on a steel armature, fibre reinforced plastics; ferrous or non-ferrous castings etc.

The layout of the nacelle 2 is generally similar to that used with a so-called bulb hydro-turbine generator in that a speed increasing gearbox 11 and an associated generator 12 can be sealed inside a casing 13 in such manner as to prevent ingress of water. As may be seen in Figure 2 the drive shaft 10 carrying the rotor 2 extends outwardly through bearings 14 and seals 15 to carry the rotor 1, the

latter being clamped or otherwise secured to the shaft

sufficiently to allow the rotor to grip the shaft 10 securely.

The external or upstream face of the rotor hub is protected by the shaped faring 6 which latter is designed to offer streamlining of the flow of water through the rotor and which, by being sealed and also filled with air, can also serve to provide bouyancy and hence reduce the effective weight of the entire assembly of the nacelle, rotor and sleeve.

It is also envisaged that an optional arrangement is for the farings 6 and 7 to be so sized and dimensioned sufficiently large enough as to render the entire sleeve assembly positively buoyant, in which case the turbine system would be involve using artificial means to force the outer sleeve 3 down to a desired working depth for the turbine, and could be permitted to float up to the surface when servicing of the turbine system was reqired, by for example, releasing arrangements (not shown) provided for holding the assembly at its operational position.

As may be seen from Figures 2A the faring 7 comrises two relatively inclined surfaces 18, defining with the sleeve 3 a generally triangular configuration.

The faring 7 may alternatively completely enclose the sleeve 3 to provide in effect a secondary outer casing of greater internal volume than would otherwise be possible so as to enhance the overall buoyancy of the sleeve and the nacelle/rotor assembly.

It is additionally envisaged that in certain circumstances

the faring 7 is as mentioned generally water tight and

open to the atmosphere and is considered to serve several beneficial purposes such as for example:

(a) streamlining the flow of water around the sleeve, this has the effect of minimising the so-called tower shadow effect on flow through the rotor and also to reduce the drag load upon the entire structure.

(b) providing buoyancy both to balance the lift of the rotor 1 or faring 7 and to add to the required up-lift when lifting the sleeve lengthwise of the column and to ease/reduce the load upon any yawing drive;

(c) to provide a passage way for services to and from the inside of the nacelle. In particular in relation to electric power cables; instrumentation and control cables.

(d) the provision of breather pipe or pipes to allow the interior of the nacelle to be vented to atmosphere. In the case of relatively large installations the faring could provide for human access from the surfaceto the nacelle for what ever purpose is desired.

(e) and to form the rear faring such that its drag can help to balance that of the rotor and nacelle when turning the rotor sideways to the current.

As is shown in Figures 5A and 5B the sleeve is supported from the top of the column 4 by a thrust bearing 19 which allows the sleeve to rotate concentrically about the axis of the column. The lower end of the sleeve 3 is contained by a radial type bearing 20 which may comprise pads of low friction material mounted upon the internal

surface of the sleeve 3 which can slide easily on a smooth track 21 applied to the outer surface of the internal column and made from sea water compatible material. Thus, by rotating the sleeve about the column 4 the nacelle 2 mounted to the sleeve 3 may be oriented in yaw so as to face in any desired direction in the horizontal plane.

The nacelle is able to rotate about the axis of the column. This rotation of the sleeve 3 and hence the movement of the rotor and nacelle in yaw is conveniently achieved by means of a slewing mechanism 22, similar in principle to those used commonly for wind turbines and for cranes, mounted upon a platform 23 at the top of the sleeve and interacting with a gear 24 or other suitable fixed reaction surface firmly attached to the top of the internal column 4. A small motor or other power source (not shown) can be made to cause controlled movement of the sleeve 3 around the column 4 so as yaw the rotor. The control can be of the servo-mechanism type including means whereby the servo-mechanism can be automatically activated to respond to operational requirements. In other words if this mechanism is activated by a control system the rotor can be set to face the oncoming current even in situations such as at sea where the direction may change by up to 180 degrees each time the tide changes to flow in the opposite direction. Moreover, and most importantly the mechanism may also be used to turn the rotor so that its plane of rotation is parallel with the direction of flow of the current in order to disable the rotation of the rotor at times when it is necessary to prevent rotation taking place. For example, if a fault condition develops, maintenance is required or it is not desirable to produce any output.

In many situations, particularly where tidal currents are to be exploited, it is envisaged that movements through no more than 180 degrees will be needed so that the rotor can be turned backwards and forwards to face currents from opposite directions as are normally to be expected in tidal waters. It is not envisaged that the sleeve and thus the rotor nacelle should rotate through more than 360 degrees thereby to avoid the resulting complications in relation to cables and the like for transmitting electrical power and any control and monitoring signals from the nacelle. It will be appreciated that if the nacelle rotation direction is reversed for each tidal half cycle then such rotation can be readily accommodated by the use of flexible cables which will permit safe interconnection of the output from the turbine to any external transmission cables.

An important aspect of the present invention is that the entire sleeve 3 together with the nacelle 2 and the rotor 1 carried thereby can be raised or lowered bodily either to remove (or to install) them or to position the rotor hub and nacelle at or slightly above the level of the water so as to be able to gain easy access during installation, recovery, inspection, maintenance and repairs etc. Figures 1 and 6 schematically illustrate respectively the operational and maintenance positions of the sleeve and the elements carried thereby.

In addition, these particular Figures also illustrate an embodiment in which a vertical mast 9 mounted to the top of the fixed column can be used as a support for raising and lowering the sleeve and its nacelle. This is a desirable but non-essential feature as an external crane

may be utilised for the same purpose. Such external

crane or other lifting equipment can be mounted upon a servicing vehicle. Alternatively floodable tanks or buoyancy tanks can be permanently or temporarily attached to the sleeve and used to cause the sleeve and its associated nacelle to lift up to the water surface.

Figure 5B schematically illustrates a convenient method for raising the sleeve and nacelle, the embodiment shown includes a winch 25 (or windlass) mounted in the housing 8 located above the sleeve 3 and which winds in a cable 26 which passes over guide pulleys at the top of the supporting mast 9 and back down the sleeve 3. By operating the winch 25 the sleeve 3 can be raised or lowered as required. Other methods of effecting the displacement of the sleeve 3 can be used such as mechanical rack and pinion arrangements with, for example, the rack attached to the fixed vertical column 4 and the pinion driven by a suitable motor drive jacking against a series of lugs/teeth securely attached to the sleeve 3, or by utilising the previously mentioned arrangements for controlling the buoyancy of the sleeve 3 and associated nacelle 2.

Figure 6 illustrates a preferred method by which a power nacelle may be attached or removed from a sleeve when it is raised above the water surface. The nacelle is attached, as is indicated in the Figure, primarily by pinning the nacelle to a bracket 27 by the pin 16, the bracket being attached to the sleeve 3 in such a manner that the complete nacelle and rotor assembly 1/2 can be rotated, by any convenient means about the pin 16 i.e., by using a chain block, winch, jacks or other lifting equipment, through 90 degrees about the pin 16 from its

operational position, so that the plane of the rotor 1

becomes horizontal. In such a position the rotor blades need to be set to pass either side of the sleeve 3.

If a floating pontoon or other vessel (not shown) is moved under the lower face of the nacelle 2 when it has been positioned with the rotor plane horizontal I.e., as in Figure 6B, then the weight of the rotor/nacelle assembly may be transfered to the vessel thereby allowing the pin 16 to be removed. Hence the assembly may be conveniently transported away from the column. A replacement rotor nacelle assembly may then be readily mounted using the reverse of the above mentioned procedures. In practice, the servicing vessel can be of the twin hulled type so that the hulls can be positioned to either side of the column 4 and sleeve 3 to ensure secure postioning during the removal and installation of a rotor/nacelle assembly.

The formation of the rotor/nacelle mounting is such that upon returning a rotor/nacelle to its operational position i.e., with its rotor plane vertical, a flat surface 28 on the nacelle i.e., that opposite to the rotor lies flat against a surface 29 provided upon the sleeve 3. Appropriate securing arrangements i.e., clips, bolts, pins etc., are engaged to hold the nacelle securely against the sleeve 3.

The cables or other services connections from the nacelle would generally be routed up the interior of the faring 7, i.e., that located to the opposite side of the sleeve to the nacelle. For such cables and other service connections to reach the nacelle a pipe or duct 17 is mounted to that side of the sleeve 3 at the level of the nacelle which couples with appropriate water tight flange

or fitting on the nacelle as indicated in Figure 2. In the event that human access is desired such flange/fitting would be dimensioned to allow for such a requirement.

The cables and connections emerging above water/sea level would be routed into the water tight containment housing 8 located either at the top of the faring 7 or if considered convenient to the top of the outer sleeve 3 such as is indicated in Figure 5. The containment 8 can house all requisite electrical interfacing equipment such as switch gear, circuit breakers, safety and monitoring equipments; computers, transformers, power conditioning components etc. The containment 8 also provides a convenient point where connectión to an external electrical network can be made.

The cable/connections to such external electrical network can either be routed downwards through the centre of the column 4 and hence threaded through a hole in its base to emerge into the water/sea or river bed for onward transmission of energy captured by the system. Alternatively the cable connections can be routed as an overhead line 30 from the mast 9 used for raising or lowering the outer sleeve and nacelle (Figure 7). It is also envisaged that in many situations a row of such turbine systems may be deployed at right-angles to a shore line and closely enough spaced so that overhead cables may be used to link them in situations where the system closest to the shore line is sufficiently close to a mast 31 mounted on shore, as is indicated in Figure 7. This latter arrangement has an advantage of reduced overall costs as compared with the use of marine underwater cabling. This arrangement is shown in Figure 7.

Furthermore, it is contemplated constructing the farings 6

and 7 sufficently large enough as to render the entire sleeve construction positively bouyant. With this arrangement the sleeve and associated turbine nacelle would be operationally deployed by using artificial means to force the outer sleeve down to the required operational depth for the turbine. With this arrangement the sleeve would be allowed to float upwards when servicing was required by, for example, releasing means for locking the sleeve in its lowered position.

If desired, the faring 7 extending solely across the reverse side of the sleeve 3 from the nacelle and rotor may alternatively completely enclose the sleeve 3, to provide a secondary outer-casing of greater internal volume than would otherwise be possible so as to enhance overall buoyancy of the sleeve/nacelle/rotor assembly.

In other possible specific embodiments the farings either at the sleeve 3 or the rotor hub or by providing the additional buoyancy chambers (not shown) may be partitioned internally into faring compartments in such a way that a turbine and sleeve may be made buoyant or heavier than water by pumping out or flooding appropriate faring compartments as a method of raising and/or lowering the sleeve/nacelle/rotor assembly.

The forgoing discussion has been directed to a single rotor installation. If desired, multiple rotor installations can be used. A twin rotor installation is schematically shown in Figure 8 in which two or more rotors/nacelles are mounted upon horizontally streamlined support members 30. With such an arrangement the rotors 1 would be arranged to rotate in opposed directions

to reduce the effects of torque reactions.

It will be understood that with multiple rotor/nacelle arrangements provision still needs to be made for rotating the rotors for yaw purposes. Figure 9 schematically illustrates a mode of providing for yawing of the twin rotors about a horizontal orthogonal axis. The full lines depict the rotor operational position and the broken lines a yawed position. With the arrangement of Figure 9 it is not necessary to be able to yaw the supporting sleeve 3 around the fixed supporting column 4 upstanding from the sea bed. Moreover, the rotors 1 may be disabled to prevent them from turning into the current by rotating the nacelles so that the rotors are horizontal with their axes pointing vertically upwards. If the entire support structure is then raised, i.e, by pumping out buoyancy tanks, the rotors can be brought to the surface for what ever purpose required.

In practice, two deployed side by side have greater width and less depth so that they intercept the upper faster layers of moving water more effectively than a single rotor of the same swept area. Also two smaller rotors permit the use of less costly transmission and rotor components than a single rotor of equivalent swept area, since such rotors rotate faster with significantly lower torque. In addition, two rotors allow more energy to be gained from the use of a single column thereby reducing installation overhead costs.

Alternative methods can be used to mount the rotor/nacelle assembly from the column 4. Figure 10 illustrates schematically the supporting of the assembly from the lower end of a support beam 32 pivoted at its upper end 33 to the top of the column 4. The operational setting for

the rotor assembly is shown in full lines and a non-operational position in which the assembly has been raised above the water surface is shown in broken lines.

The raising and lowering of the nacelle could be through the use of lifting equipment from a support vessel or by using buoyancy tanks (the latter possibility not being shown)

Figures 11 and 12 schematically illustrate an embodiment in which the support beam 32 is centrally pivoted as at 34 to the top of the column 4 so that a counterbalancing of the rotor/nacelle assembly can be achieved by a counter-balance weight 35.

Figure 11 shows the operational position of the rotor/nacelle assembly and Figure 12 a non-operational position.

It is to be noted that the above discussed column mounted current turbine system can be used with a water-filled (demineralised water) generator, in which case there would be no need to vent the nacelle to atmosphere.

CLAIMS

1. A flowing water drivable turbine system, wherein a turbine assembly is mounted for operational cooperation with a flow of water by means of an upstanding column.

2. A flowing water drivable turbine system as claimed in claim 1, wherein the turbine assembly is mounted for rotation about the upstanding axis of the column, the arrangement being such that the turbine assembly can be enabled operationally to undergo rotation with respect to a direction of water flow thereby to enable the rotor assembly operationally to align with the flow of water.

3. A flowing water drivable turbine system as claimed in claim 1 or 2, wherein the mounting of the turbine assembly to said column is such that the turbine assembly can be raised or lowered with respect to the column and thus with respect to the surface of the water.

4. A flowing water drivable turbine system including a turbine rotor assembly mounted for rotation about the longitudinal axis of a vertically arranged column whereby the turbine assembly can be enabled operationally to align with the flow of water, the mounting of the turbine assembly to said column being such that the turbine assembly can be raised or lowered with respect to the column and thus with respect to the surface of the water.

5. A flowing water drivable turbine system as claimed in any one of the preceding claims, wherein the turbine assembly includes an elongate nacelle shaped housing shaped and dimensioned so as to optimise water flow thereby, and wherein one end region of the nacelle is mounted to the column and the rotor of the assembly is located towards the other end of the nacelle, the shaping of the hub region of the rotor being such as effectively to form part of the overall shaping of the nacelle.

6. A flowing water drivable turbine system as claimed in any one of the preceding claims, wherein the turbine assembly is mounted by way of a sleeve like housing carried by the column in such manner that the sleeve is both vertically displaceable and rotatable with respact to the column.

7. A flowing water drivable turbine system as claimed in claim 6, and wherein the turbine assembly can be be raised to facilitate access to the turbine assembly and particularly to the nacelle and the rotor of the turbine assembly.

8. A -water drivable turbine system as claimed in claim 6 or 7, and wherein turbine assembly is mounted to the sleeve in such manner that the turbine assembly can be moved to positions in which the rotor is operationally disabled by being turned edge on to the water flow.

9. A flowing water turbine system as claimed in claim 6 or 7, wherein an elongate faring or guide structure is mounted to the sleeve to be so responsive to the direction of water flow as automatically to rotate the turbine assembly to maintain the rotor operationally facing the flow of water.

10. A flowing water turbine system as claimed in any one of the preceding claims 6 to 9, wherein arrangements are made or provided for increasing the buoyancy of the turbine assembly and the sleeve structure thereby to reduce the effevtive weight of the turbine assembly and its associated sleeve structure.

11. A flowing water turbine system as claimed in claim 10, wherein the buoyancy of the turbine assembly and the sleeve structure are rendered positively buoyant whereby artificial maens are required to maintain the turbine assembly at a required operational depth within the water flow, the arrangement being such that the turbine assembly can be enabled to move upwards to the surface of thr water for a required purpose.

12. A flowing water turbine system as claimed in any one of the preceding claims 6 to 11, and wherein the dimensions and shaping of the sleeve and faring are such as to minimise the effects of column shadow on flow through the rotor and also to reduce drag load on the column.

13. A flowing water turbine system as claimed in in any one of the preceding claims, and including means for facilitating slewing of the turbine assembly about the column.

14. A flowing water turbine system as claimed in claim 13, and including means for automatically activating the means for the turbine assembly, the arrangement being such that the rotor of the turbine assembly can be selectively set to face oncoming water flow.

15. A flowing water turbine system as claimed in claim 13 or 14, and wherein the slewing means is selectively actuatable to enable movement of the turbine assembly to a position in which the plane of rotation is parallel to the direction of water flow the arrangement being such as to prevent rotor rotation.

16. A flowing water turbine system as claimed in any one of the preceding claims 1 to 15, wherein the overall length of the column is such that it projects above the surface level of the water in which the column is erected, and wherein means are provided for enabling the turbine assembly to be raised above said water surface level.

17. A flowing water turbine system as claimed in claim 16, and including means for raising and lowering the turbine assembly with respect to a level above the water surface level.

18. A flowing water turbine system, as claimed in any one of claims 1 to 17, and wherein the column is arranged to support at least two turbine assemblies.

19. A flowing water turbine system as claimed in any one of claims 6 to 16, and wherein two turbine assemblies are mounted from a horizontal support member that is connected with a common sleeve mounted to said column, and wherein the directions of rotation of the rotors of said turbine assemblies are in oppoased directions to facilitate reduction of the effects of torque reactions.

20 A flowing water turbine system as claimed in claim 19, and wherein each turbine assembly is connected with associated means for enabling the to movement of the axes of rotation of the rotors into a vertical direction so as effectively to prevent operational rotation of the rotors.

21. A flowing water turbine system, constructed and arranged to operate substantially as hereinbefore described with reference to Figure 1,2 and 2A; Figure 3, Figure 4, Figures 5 and 5A; Figures 6A and 6B; Figure 7, Figures 8 and 9; Figure 10 and Figures 11 and 12 of the accompanying drawings.

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Application No:	GB 9706464.6	**Examiner:**	Ken Strachan
Claims searched:	All	**Date of search:**	1 May 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): F1S: S28A, S28B1, S28B2, S28BX, S28Z;

Int Cl (Ed.6): F03B: 13/12, 13/14, 13/16, 13/18, 13/22, 13/26.

Other: -

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 2,247,925A	(Filipov) See figs. 1 and 2; notice blades 9 on wheel 14; columns 3; slides 2 for vertical motion.	1, 3, at least.
X	GB 2,002,458A	(Sandgänger) See figs. 1, 2, and 8; notice blades 15 on wheel 10; column 4; bearing 9 for vertical (tilting) motion.	1, 3, at least.
X	WO 88/04362A1	(Pedersen) See figure 1; notice turbines 21; column 5; capacity of entire unit to swing on mooring line 2 about mooring 1.	1, 2, at least.
X	WO 80/02181A1	(de la Roche) See figure 1; notice turbines 7; rotatable column 5.	1, 2, at least.
X	US 4,914,915	(Linderfelt) See figure 1; notice turbine 70; main column 22; and turbine column 28 which may be raised and lowered relative to column 22.	1, 3, at least.
X	US 4,843,249	(Bussiere) See figure 1; notice turbine 22; columns 10; and raising and lowering mechanism 32, 34, 36.	1, 3, at least.

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

The Patent Office

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Application No: GB 9706464.6
Claims searched: All

Examiner: Ken Strachan
Date of search: 1 May 1997

Category	Identity of document and relevant passage		Relevant to claims
X	US 4,296,602	(Hales) See figure 2; notice turbine 18; column 35; and raising and lowering mechanism 22, 23, 24.	1, 3, at least.

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.